



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : C21C 5/52, 5/56		A1	(11) International Publication Number: WO 96/41896 (43) International Publication Date: 27 December 1996 (27.12.96)
(21) International Application Number: PCT/EP96/02525 (22) International Filing Date: 11 June 1996 (11.06.96)		(81) Designated States: AU, BR, CA, CN, CZ, JP, KR, NZ, PL, TR, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).	
(30) Priority Data: 195 21 518.4 13 June 1995 (13.06.95) DE		Published <i>With international search report.</i>	
(71) Applicant (<i>for all designated States except US</i>): L'AIR LIQUEE [FR/FR]; 75, quai d'Orsay, F-75322 Paris Cedex 07 (FR). (72) Inventors; and (75) Inventors/Applicants (<i>for US only</i>): DELOCHE, Daniel [FR/FR]; 1, square Maurice-Denis, F-92190 Meudon (FR). BROTZMANN, Karl [DE/DE]; Von-Scheffel-Strasse 34, D-92224 Amberg (DE).			

(54) Title: METHOD FOR AN IMPROVED ENERGY INPUT INTO A SCRAP BULK

(57) Abstract

Method for improving the energy input during the heating and melting of a scrap bulk, in which a channel is burned into a scrap bulk and additional energy for the heating and melting of the scrap bulk is input through this channel, wherein said method is characterized in that the said channel is burned into the scrap bulk by means of a hot, oxygen-containing gas jet.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgyzstan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic	KR	Republic of Korea	SE	Sweden
CG	Congo	KZ	Kazakhstan	SG	Singapore
CH	Switzerland	LI	Liechtenstein	SI	Slovenia
CI	Côte d'Ivoire	LK	Sri Lanka	SK	Slovakia
CM	Cameroon	LR	Liberia	SN	Senegal
CN	China	LT	Lithuania	SZ	Swaziland
CS	Czechoslovakia	LU	Luxembourg	TD	Chad
CZ	Czech Republic	LV	Latvia	TG	Togo
DE	Germany	MC	Monaco	TJ	Tajikistan
DK	Denmark	MD	Republic of Moldova	TT	Trinidad and Tobago
EE	Estonia	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	UG	Uganda
FI	Finland	MN	Mongolia	US	United States of America
FR	France	MR	Mauritania	UZ	Uzbekistan
GA	Gabon			VN	Viet Nam

METHOD FOR AN IMPROVED ENERGY INPUT INTO A SCRAP BULK

The output-limiting step in the heating and melting of scrap is the transfer of energy to the scrap bulk. As a result, the melting phase may be supported, for example, by burners 5 installed on the side walls in the case of electric arc furnaces. The transfer of heat into the scrap bulk by these burners, however, is limited since the conduction of heat through the large interstitial volume of the scrap charge is poor. The energy which can be introduced by burners is therefore limited to a max. 10% of the total energy required for scrap melting.

- A known converter method for scrap melting provides for melting the scrap column 10 from below by means of bottom nozzles that are operated with oxygen and finely divided coal. This achieves an optimal transfer of the heat of the hot combustion gases to the scrap bulk. In a variant of this method, coke is charged at the bottom of the converter before the scrap is added and the coke is then burned using oxygen. In small converters it has proven possible to convert scrap to liquid steel with this method at a coke consumption of approximately 220 kg.
- 15 Additional energy is transferred to the scrap from above through combustion of the reaction gases using an oxygen jet.

In another method, a natural gas- or oil-oxygen burner is installed in the side wall immediately above the floor of the converter. This method does make possible melting of the scrap, but a considerable portion of the iron is oxidized, and the liquefied iron must be 20 removed from the converter at a temperature just above the melting point in order to undergo post-treatment in a separate container.

- European Patent 0 350 982 A1¹ discloses a method for improving the energy input during the heating and melting of a scrap bulk. In this method, a channel is burned into the scrap bulk by a burner having the form of a lance and an oxygen lance is then inserted into the 25 channel. This lance insertion has proven to be impossible to execute in actual practice.

In summary, one should note that in all the heretofore known methods it has not been possible to achieve a substantial transfer of energy from the combustion of fossil fuels, whether

coal, oil, or natural gas, into a scrap bulk without concomitant strongly perturbing secondary reactions and with the required high thermal efficiency.

The object of the invention is the transfer of energy into a scrap bulk at high thermal efficiencies and without the appearance of perturbing secondary reactions.

5 The aforesaid object is achieved by a method for improving the energy input during the heating and melting of a scrap bulk, in which a channel is burned into the scrap bulk and additional energy for the heating and melting of the scrap bulk is input through this channel, wherein said method is characterized in that the said channel is burned into the scrap bulk by means of a hot, oxygen-containing gas jet.

10 It has surprisingly been found that a hot, oxygen-containing gas jet can burn a channel into a scrap bulk within only a few minutes.

Thus, it has been possible, for example, with a central nozzle to burn a channel approximately 20 cm in diameter and 3 m deep within 3 minutes using a hot air jet of 2000 m³/hour and a draft temperature of 1400°C, an exit velocity from the hot air nozzle of 600 m/s, 15 and the addition of 100 Nm³/hour natural gas.

A channel can be burned into the scrap bulk without the addition of fossil fuel using a hot, oxygen-containing gas jet alone. However, channel burning is preferably executed in the presence of fossil fuel. The fossil fuel can be present in the scrap bulk, but is preferably added to the gas jet. It should be understood that both variants, addition of fossil fuel to the scrap 20 bulk and to the gas jet, are [simultaneously] possible.

Mainly natural gas, but also petroleum, coal, and coke will be used as the fossil fuel.

The quantity of fossil fuel addition is advantageously kept low enough that free oxygen will still be present in the gas jet. The free oxygen supports a more rapid formation of the opening in the scrap bulk. In addition, combustible substances, which are always present in a 25 scrap bulk, will be burned within the scrap column, which leads to a particularly favorable energy utilization.

Natural gas is particularly preferred as the fossil fuel. At approximately 2800°C, dissociation into radicals takes place during combustion with oxygen. The gases diffuse into the scrap bulk and at the lower temperature release their recombination energy to the scrap.

This reliably secures a particularly good energy transfer. The flame temperature should be as high as possible and is preferably at least 2500°C.

After an initial phase of approximately 1 to 2 minutes, the fossil fuel is most effectively added so as to secure the latest possible reaction within the gas jet. Thus, for example, natural 5 gas is appropriately added through a nozzle in such a manner that a weak swirling with the oxygen-containing gas jet occurs. In the case of coal, it may be preferable to use the coarsest possible fraction of finely divided coal, that is, to use coal particles in the range of 0.1 to 1 mm which then burn substantially only when they are within the channel created by the gas jet.

Hot air, oxygen-enriched hot air, and also pure oxygen can be used as the hot, oxygen-containing gas. In the case of oxygen-enrichment of the gas jet, oxygen enrichment up to 30% 10 is preferred. This can be increased, however, up to preferably 60% when cold oxygen is used for enrichment. Viewed from the perspective of the injection nozzles, it is significantly simpler to blow in hot air rather than oxygen. Hot air can be injected with ceramic nozzles, but oxygen, on the other hand, requires water-cooled nozzles.

To achieve the highest possible thermal efficiency it will be desirable to set the 15 temperature of the oxygen-containing gas jet as high as possible. Temperatures between 1000°C and 1600°C have proven to be particularly advantageous in the case of hot air. However, gas jets with higher temperatures can also be used advantageously. The gas jet preferably has a temperature of at least 500°C. Oxygen can be relatively unproblematically 20 preheated up to 1200°C. The use of hot air as well as oxygen-enriched hot air offers two essential advantages over the injection of pure cold oxygen: due to the high velocity — a consequence of the hot air having a velocity more than twice as high as the speed of sound — and due to the higher quantity of gas, a substantially higher impulse is present than for the introduction of pure oxygen. This impulse supports the burning-in of the opening. While the 25 free oxygen present greatly favors burning of the opening, the nitrogen present provides a certain protection from oxidation during melting.

Pure hot oxygen, however, can also be used. The speed of sound is higher at higher temperatures and is, for example, approximately 900 m/s for pure oxygen at 1200°C. Thus, a higher impulse is also attainable with hot oxygen.

30 A practical problem at the beginning of channel burn-in is that a gas jet with the optimal high speed may be initially reflected by scrap pieces. It is therefore appropriate to operate for a short period of time, perhaps in the range of one or more minutes, at a substantially reduced

speed, for example, 10 to 30% of the speed of sound, and down to approximately 100 m/s. A high fossil fuel addition is also recommended in the initial phase.

It should be stressed that a cold zone is formed directly in front of the gas injection nozzle. This may be due to a suctioning of the surrounding air. In any case, the scrap is not even oxidized.

After the first phase of an optimal channel formation, it is important to bring as much energy as possible into the channel. This is preferably achieved by the highest possible flame temperature, for example, by the use of natural gas and hot air with a flame temperature of 2800°C.

10 An important criterion is also the high velocity of the gas jet. The velocity of the gas jet should be at least 300 m/s. When using an oxygen gas jet, the velocity should be at least 500 m/s. The exit velocity of the gas jet is preferably 50 to 100% of the speed of sound. The speed of sound rises with temperature and at the aforementioned high temperatures is approximately 3 times higher than the speed of sound at room temperature.

15 An advantageous use of the method in accordance with the invention is to supply substantial quantities of additional energy to an electric arc furnace mainly during the scrap melting phase. Thus, for example, three hot draft injection nozzles with diameters of 80 mm were installed in a 100-ton electric arc furnace in the upper area of the side walls. These nozzles were operated at a hot draft flow of 2000 Nm³/h per nozzle and an oxygen enrichment of 30% during the melting and ensuing refining phase, wherein 300 Nm³/h oxygen was additionally added cold to the hot draft jet. The hot draft temperature was 1400°C. Fuel was added in the manner previously described, wherein after scrap melting essentially only gases formed by reaction were still suctioned in by the hot air jet and therefore no further addition of fuel into the hot draft jet was necessary. The nozzles were arranged in such a way that they 20 blew into the space between the furnace wall and the electrodes, slanted downwards at an angle of approximately 10°. It is desirable that the jets be aligned so as to strike at a point at the bottom where the liquid steel will be formed most rapidly. If the jet strikes refractory material after burning through the scrap column, this material will be melted away in a short period of time. This is also true for the water-cooled side walls of electric arc furnaces.

25 30 In general, the gas introduction nozzles can be installed anywhere, but preferably are installed at least 30 cm above the bath surface — when using oxygen, at least 80 cm above the bath surface.

The consumption of electric energy was reduced from 430 kWh to 280 kWh in an electric arc furnace equipped with the device in accordance with the invention. The melting time of 58 minutes was simultaneously reduced to 42 minutes.

Another suitable embodiment consists of the use in the channel of two hot draft jets
5 blowing in opposite directions, instead of one nozzle, with the result that three injection sites in the side wall will yield a total of six injection jets.

The method in accordance with the invention is not only suitable for use in electric arc furnaces. A scrap charge can also be melted using the method in accordance with the invention without the additional use of other energy sources. Fossil energy sources must then
10 be introduced into the scrap bulk in suitable form, for example, by charging with the scrap at approximately 100 kg coal per ton. A portion of the coal can be blown in through nozzles as soon as a liquid sump has been formed. After melting the jet will act, in the known manner, as a post-combustion jet for additional energy input in order to reach the necessary tapping temperature.

15 The hot air is advantageously produced using a device developed specifically for this purpose, the so-called pebble heater as described in PCT WO 93/923585. The pebble heater is advantageously mounted directly on the container in the vicinity of the injection nozzles.

PATENT CLAIMS

1. Method for improving the energy input in the heating and melting of a scrap bulk, in which a channel is burned into a scrap bulk and additional energy for the heating and melting of the scrap bulk is input through this channel, characterized in that the channel
5 is burned into the scrap bulk by means of a hot, oxygen-containing gas jet.
2. Method according to Claim 1, characterized in that the channel is burned into the scrap bulk in the presence of fossil fuel.
3. Method according to Claim 1 or 2, characterized in that fossil fuel is added to the gas jet.
- 10** 4. Method according to one of Claims 1 to 3, characterized in that a hot air jet is used as the gas jet.
5. Method according to one of Claims 1 to 4, characterized by the use as the gas jet of a hot air jet enriched up to 30% oxygen.
6. Method according to one of Claims 1 to 4, characterized by the use as the gas jet of a
15 hot air jet enriched with cold oxygen up to 60%.
7. Method according to one of Claims 1 to 6, characterized in that the temperature of the gas jet is at least 500°C.
8. Method according to one of Claims 1 to 7, characterized in that the temperature of the gas jet is 1000°C to 1600°C.
- 20** 9. Method according to one of Claims 1 to 8, characterized in that the exit velocity of the gas jet is 50 to 100% of the speed of sound.
10. Method according to one of Claims 1 to 9, characterized in that the velocity of the gas jet is at least 300 m/s.
11. Method according to one of Claims 1 to 10, characterized in that the velocity of an
25 oxygen gas jet is at least 500 m/s.
12. Method according to one of Claims 1 to 11, characterized in that the velocity of the gas jet in the initial phase is 10 to 30% of the speed of sound.

13. Method according to one of Claims 1 to 12, characterized in that the fossil fuel added to the gas jet essentially burns only when in the channel created by the gas jet.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 96/02525

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C21C5/52 C21C5/56

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C21C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US,A,5 286 277 (AIZATULOV RAFIK ET AL) 15 February 1994 *abstract;figures;claims; col. 21,line 45 to col. 22, line 13*	1-13
X	PATENT ABSTRACTS OF JAPAN vol. 012, no. 117 (C-487), 13 April 1988 & JP,A,62 238318 (DAIDO STEEL CO LTD), 19 October 1987, see abstract	1
Y	PATENT ABSTRACTS OF JAPAN vol. 009, no. 309 (C-318), 5 December 1985 & JP,A,60 149710 (SHIN NIPPON SEITETSU KK), 7 August 1985, see abstract	1-13
	---	-/-

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

4 October 1996

Date of mailing of the international search report

11.10.96

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentzaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax (+31-70) 340-3016

Authorized officer

Oberwalleney, R

INTERNATIONAL SEARCH REPORT

Int'l Application No
PCT/EP 96/02525

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE,A,27 59 129 (CALDERON ALBERT) 12 July 1979 see claims ---	1-13
A	GB,A,2 177 118 (BRITISH STEEL CORP) 14 January 1987 see abstract; claims; figures ---	1-13
A	PATENT ABSTRACTS OF JAPAN vol. 008, no. 046 (C-212), 29 February 1984 & JP,A,58 204111 (MITSUBISHI JUKOGYO KK), 28 November 1983, see abstract -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 96/02525

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A-5286277	15-02-94	AU-A-	4523593	29-03-94
		CA-A-	2136731	17-03-94
		CN-A-	1088620	29-06-94
		EP-A-	0649478	26-04-95
		RU-C-	2034040	30-04-95
		US-A-	5378261	03-01-95
		WO-A-	9405815	17-03-94
		US-A-	5417740	23-05-95
		ZA-A-	9303641	21-12-93
DE-A-2759129	12-07-79	NONE		
GB-A-2177118	14-01-87	DE-A-	3620517	08-01-87
		JP-A-	62027513	05-02-87
		US-A-	4701216	20-10-87